

ered. A thermometer whose bulb is under the water will give the temperature of the water and the air within it, and, if the water be well stirred, all will have the same temperature.

An early modification of this simple barometer was for a long time manufactured by expert glass blowers in Florence, and was called the Florentine experiment. In this arrangement the inverted flask was made quite small, and weighted so that it floated freely like a small balloon in a jar of water; when the temperature of the water rose, or when the atmospheric pressure diminished, the air within the flask expanded and the density of the balloon diminished, so that it rose to the surface. If, however, the glass flasks are hermetically sealed so that the air within them can not expand and change their density to any extent; then, if the water in the jar becomes warmer, the flasks will descend because their own density will then be greater than that of the water. If, again, the open mouth of the jar be hermetically sealed, inclosing air above the water, we have a new condition, viz. the external atmospheric pressure has no longer any influence, while the changes of temperature have a twofold influence; by expanding the water its density is diminished, but by expanding the air above the water the quasi atmospheric pressure within the jar is increased. These four combinations, namely, closed or open flasks floating in closed or open jars of water, formed what are known as the Florentine and the Stuttgart experiments with the Cartesian divers, and the phenomena that they exhibited were widely discussed by Europeans in the seventeenth century.

THE CARBONIC ACID GAS IN THE ATMOSPHERE.

Both geology and agriculture are interested equally with meteorology in the part played by the small quantity of carbonic acid gas that exists in the atmosphere. The leaves absorb and assimilate a portion; the falling raindrops and the surface water of the ocean absorb another portion; it is exhaled from the lungs and given off in still greater quantities from every burning substance. It may accumulate temporarily in some regions, but the slow diffusion and swifter winds carry it away. It ought to diminish as we ascend above the earth's surface, but the rapidly rising and falling currents of air tend to preserve a fairly uniform mixture very much as they do in the case of aqueous vapor. Evidently there is a general balance between the production and absorption of carbonic acid gas, so that, like the temperature of the air and the quantity of rain or any other meteorological element, we find no great progressive secular increase or diminution. The following paragraphs, reviewing the latest addition to our knowledge of this subject, are translated from Wollny's *Forschungen* (1895, Vol. XVIII, p. 409):

"In order to arrive at a more accurate knowledge of the distribution of carbonic acid gas in the atmosphere, S. A. Andrée, the Swedish aeronaut, collected samples of air in exhausted tubes on most of his balloon voyages, and took care, moreover, to do this while the balloon was descending and as far as possible from the car of the balloon in order to avoid contamination from any gases that might come from the balloon itself. These samples were analyzed at the high school in Stockholm by Miss Palmqvist, who had already published an extensive investigation into the carbonic acid gas contained in the atmosphere over the experimental field at Stockholm.

"As compared with the data for the earth's surface near Stockholm, published by Palmqvist, and those for Wexholm, published by Selanders, the Andrée results, as shown in a table arranged according to the altitudes of the respective layers of air do not prove any diminution of carbonic acid gas with altitude up to the highest point, 4,300 meters, attained in these balloon ascensions. On the other hand the percentages of carbonic acid gas by volume throughout the different

strata of air are very much the same as those observed at the surface of the earth. On the average we find in 10,000 volumes at the earth's surface from 3.03 to 3.20 volumes of carbonic acid gas; at altitudes of 1,000 to 3,000 meters, 3.23 volumes; at altitudes of 3,000 to 4,000 meters, 3.24 volumes. On the other hand notable differences are remarked when we arrange the percentages for the higher and freer strata of air according to the direction of the wind, although the differences that are thus brought out are not entirely systematic, as might have been expected, because in the atmosphere many currents intersect so that more or less appreciable mixtures of masses of air having various percentages of carbonic acid gas must occur. But this apparent dependence on the wind must suggest further investigation as to how far the carbonic acid gas present in the atmosphere depends upon the place from which the air came, and especially on the contact of this air with the earth's surface, since it is to be assumed that the absorption and development of carbonic acid gas takes place at the earth's surface and not in the atmosphere.

"From this point of view the author has, by utilizing the weather reports of the Central Meteorological Institution at Stockholm, classified the measurements of carbonic acid gas at the two stations above mentioned, according as they were made within areas of barometric maxima or minima, and has compared these values with the corresponding monthly means. At both stations the percentages of carbonic acid gas are found to be above the monthly means in the maxima, but below in the minima. If we may generalize this result, it might be said that a descending mass of air brings with it a higher percentage of carbonic acid gas, which is subsequently diminished by absorption near the earth's surface, so that the ascending current has a smaller percentage.

"The hypothesis that the larger percentage in the maxima is caused by the calmness of the atmosphere seems to be disproved by the fact that scarcely half of the cases cited in Andrée's table showed a perfect calm and that these occurred in the months of December and January, when a large quantity of carbonic acid gas is thrown into the quiet atmosphere by the combustion of wood and coal in the ordinary industrial operations. We must indeed assume that air which is rich in carbonic acid gas descends to the earth's surface from the upper strata of the atmosphere; but we must not conclude that, in general, the atmosphere should therefore be found to be richer in carbonic acid gas during high barometric pressure and poorer during low pressure. On the contrary, other matters ordinarily make themselves felt in such a way that the influence of high pressure and descending currents is entirely obliterated and pushed into the background. The observations at Wexholm demonstrate that the north and northwest land winds contain much more carbonic acid gas than the southeast ocean winds, whose air, flowing over the surface of the Baltic, has suffered a great loss of carbonic acid gas.

"In order to test the question whether the air within an area of barometric high pressure is really richer in carbonic acid gas than in a barometric minimum one must take account of the above-mentioned and other disturbing influences. For the present Andrée thinks himself justified in adopting the conclusion that in the region investigated by him the lower atmospheric strata received more carbonic acid gas from the upper strata than from the earth's surface. This agrees with the observation made by Nansen on his Greenland expedition at altitudes of 2,300 to 2,700 meters and at temperatures of -19.4° to -24° C. in a locality where the occurrence of carbonic acid gas arising from artificial combustion was out of the question; here it was found that the percentage of carbonic acid gas was as large and even larger than in the experimental field near Stockholm. Andrée does not consider that it is yet time to offer any explanation of this larger percentage

of carbonic acid gas, and nothing can be said as yet as to whether these results for high northern latitudes occur also in other regions.

"The question here raised is one of great importance in the theory of the interaction of the atmosphere and the earth, and it can only be brought to a definite solution when the greatest

possible number of investigations into the percentages of carbonic acid gas in the atmospheric strata are carried out by means of balloon voyages. Observations made upon high mountains can not replace those made on balloon voyages, because on the mountain tops we are still under the influence of the absorption by the earth's surface."

METEOROLOGICAL TABLES.

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Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (. . .).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives, for 82 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891-'92, p. 29.

Table V gives, for 67 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891-'92, pp. 26 and 30.

Table VI gives, for 136 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891-'92, p. 19.

Table VII gives the danger points, the highest, lowest, and

mean stages of water in the rivers at cities and towns on the principal rivers; also the distance of the station from the river mouth along the river channel.

Table VIII gives the maximum, minimum, and mean readings of the wet-bulb thermometer for 135 stations, as determined by observations of the whirled psychrometer at 8 a. m. and 8 p. m., daily.

The difference between mean local time and seventy-fifth meridian time is also given in the table.

Table IX gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division one may obtain the average resultant direction for that division.

Table X gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table XI gives, for 42 stations, the percentages of hourly sunshine as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table XII gives the records of hourly precipitation as reported by stations equipped with automatic gauges, of which 37 are known as float gauges and 7 as weighing rain and snow gauges.

Table XIII gives the record of excessive precipitation at all stations from which reports are received.

Table XIV gives a record of the heaviest rainfalls for periods of five and ten minutes and one hour, as reported by regular stations of the Weather Bureau furnished with self-registering rain gauges.

Additional information concerning the tables will be found in the January, 1895, REVIEW.